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Moisture Retaining Materials for Tree Seedling Packaging: A Literature Review

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ABSTRACT

A literature review on the use of moisture retaining material for seedling packaging revealed that seedling moisture content could be preserved several ways. Moisture retaining materials were considered necessary in open packaging systems, such as burlap bales or containers which permit air exchange during storage or handling. Vapor proof containers which maintain high relative humidity (95–99.9%), eliminate desiccation and therefore do not require moisture retaining materials. However, seedlings packaged under stressful conditions may benefit from the addition of damp moss or root dipping, provided free water in the container is avoided.

Moisture retaining materials are recommended for frozen storage for private orders, which may be opened and resealed several times during planting, and for seedlings subjected to excessive drying conditions during the lifting or handling process.

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Introduction

All bare root nursery stock is packaged to facilitate handling and minimize deterioration between the time of lifting and outplanting. The outer wrapper, which was lacking near the turn of the century, has since included burlap, celery crates, wire or plastic mesh, cardboard boxes, plastic boxes, paper bags and plastic bags. Wax coatings, polyethylene liners or special sealants have also been used to enhance durability or effectiveness of the package. A second component of packaging includes additives to the container, such as moisture retaining materials to preserve freshness. Sphagnum moss has been widely used as the moisture retaining material in Ontario since 1908 (Mullin 1956). However, with the use of moisture-proof packages in all Ontario nurseries, the necessity for adding moisture retaining materials to the package of trees has been questioned.

The purpose of this report is to review the literature on the use of moss and other moisture retaining materials during packaging, storage and handling and to identify the current status of the use of moisture retaining materials as determined from a telephone survey of Ontario government nurseries. Other literature reviews of overwinter or spring storage of conifer seedlings include a general review of cold storage (Hocking and Nyland 1971), the pathological and physiological deterioration of planting stock in cold storage (Navratil 1973), storage problems of southern pines (Williston 1974), and a review of moulding during storage (Hopkins 1975, Venn 1980).

Early Work

Moss became the prevalent moisture retaining material for bare-root coniferous seedlings when Leslie (1945) used both peat and sphagnum moss around the roots of seedlings in his benchmark overwinter storage trials. Storage and shipping of stock in burlap bales and wooden crates started around 1952, and Mullin (1954) attributed better survival of seedlings packed in crates for shed storage to the extra damp moss which they contained. A trial comparing four moisture retaining materials including treated and untreated wood excelsior, purchased sphagnum moss and locally collected moss led to a recommendation for moisture retaining materials to be used around the roots of all trees as a means of preserving vigour (Mullin 1956). Wilner and Vaartaja (1958) attributed seedling weight loss to moisture loss during storage and recommended the use of moist peat as a packaging material. Finally, Leech (1959), in a follow-up of an earlier trial by Mullin, found no difference in height growth in the field between stock stored in burlap bales and wooden crates as long as moss was used as a moisture retaining material during packaging.

The results of these early Ontario trials were influential in establishing present nursery stock handling guidelines (Anonymous 1975) and ensured the widespread use of moss as a moisture retaining material in most bare-root packaging.

Types and Sources of Moss

Seventy percent of the moss used in various research trials between 1954 and 1981 and documented in this report was of the sphagnum variety.

However, the age, relative purity, degree of decomposition and pre-packaging treatments were highly variable. Most of the remaining 30 percent of reported trials used a commercially collected or prepared peat moss, much of which was probably sphagnum in origin. Commercial peat is also a highly variable product depending upon supplier and source. The effectiveness of peat moss as a moisture retaining material was evaluated by Powells and Schubert (1953), Wilner and Vaartaja (1958), Duffield and Eide (1959), Langstrom (1970), Hocking (1971), Hocking and Ward (1972), Stein (1977), Webb and von Althen (1980) and Venn (1981). Mullin (1956, 1973) reported comparisons of locally collected peat moss with commercial varieties of varying quality but there was little evidence to suggest the superiority of either sphagnum or peat moss.

In Ontario bare root nurseries, the type and source of moss used for packaging is quite variable. St. Williams, Orono, Midhurst and Kemptville nurseries all receive and use commercially collected sphagnum moss from sources that include central Ontario, northern Ontario and the USA. In Thunder Bay, Swastika, Chapleau and Gogama nurseries, locally collected sphagnum moss is usually used. Dryden nursery on the other hand uses various sources of peat or sphagnum depending upon availability.

Packaging Materials and Moisture Relations during Storage

Moisture is necessary for plant health and vigour and thus there has been an ongoing search for a satisfactory means of preserving plant moisture following packaging. Powells and Shubert (1953) did a comparative study of various moisture retaining materials from which they concluded that both vermiculite and peat moss were superior to shingle tow or sawdust. Bales with sphagnum moss preserved seedling moisture better than those packed with shingle tow (Deffenbacher and Wright 1954). Mullin (1954) attributed the higher survival of seedlings in crates over bales to the larger volume of moss in crates. On the other hand, Mullin (1956) found no difference between the moisture retaining ability of sphagnum moss, poplar excelsior and treated wood excelsior when used in burlap bales.

A note of caution about the use of shingle tow was raised by Krueger (1963, 1968). He reported on the role of toxins (thujaplicins), which are associated with shingle tow and can reduce seedling performance after outplanting. These thujaplicins are toxic to seedlings, but the shingle tow used in his studies had concentrations which were too low to cause heavy mortality.

Faulkner and Aldhous (1957, 1958) suggested that the high moisture content necessary in stored seedlings could be preserved by wrapping stock in polyethylene but that plants do not store as well with wet foliage as they do with dry foliage (Faulkner and Aldhous 1959). Therefore, they recommended that stored stock should not be exposed to free water. However, Wycoff (1960) found that watering burlap bales with a special perforated tube improved seedling performance even when packed with moist sphagnum moss. This would suggest that strategies for preserving plant moisture during storage may depend upon method of packaging.

Modern packaging procedures using multi-walled Kraft bags with an inner polyethylene laminate together with peat moss were first reported by Duffield and Eide (1959). Lanquist and Doll (1960) then found that polybags with no added moisture retaining material maintained seedlings in a state

which appeared more vigorous than those packed in wooden crates with a combined wood-shaving and vermiculite moisture retaining material. Burgar (1962) also successfully used a polyethylene bag without additional moisture retaining material. However, watering was still recommended for seedlings stored in burlap bales and wooden crates, even when packed along with moss (Eliason 1962, Burgar 1962). Early work with frozen and cold overwinter storage of red pine, white pine and white spruce (Mullin and Bunting 1970, 1972) also showed the clear superiority of Kraft bags with a polyethylene insert over the burlap bale when both included moss as a moisture retaining material.

By the early 1960's, desiccation was recognized as the major cause of reduction in seedling vigour during storage and was considered preventable by either open packaging (bales or crates with moss) combined with watering or by closed packaging (polyethylene bags) with or without a moisture retaining material. However, the mechanism of damage to the stock and the interaction between packaging methods, seedling condition and duration of storage were still not well understood. Therefore, other products were developed and tested for their effectiveness in preventing moisture loss from seedling roots during storage. Bland (1962) dipped roots in clay and placed seedlings, without moss, in polyethylene bags and found that trees remained in excellent condition for six weeks. "Mudding", a procedure similar to the clay dip, was used by Cram et al. (1966), who noted a loss in moisture from mudded seedlings stored in burlap bales but not from seedlings stored in polyethylene or burlap bales with moss. Seedling survival was reduced on clay dipped loblolly pine seedlings without moss (Williston 1967) although during exposure, clay dipped seedlings were less susceptible to desiccation. In addition, Chedzoy (1968) suggested that seedling tops may get encrusted with dirt and mud when the roots are dipped and that this may be detrimental to storage and eventual field performance. Operational use of a clay root treatment was suggested by Wynia (1972) but reports by Ouston and Stein (1972) recommended that clay dipping not be used for extended storage. By 1972, no nurseries were using clay or mud root dipping operationally (Hocking 1972). Several authors later confirmed the inferiority of clay dipping to either the Kraft-polyethylene bag with moss or with water dipping (Mullin 1976, Stein 1977, Mullin and Hutchison 1977, Mullin and Bunting 1979).

Synthetic compounds for retaining seedling moisture during storage have also been developed. Adams and Eden (1968) compared four chemical plant conditioners; Shell 4901, 3 Rutex treatments and three packaging variations with Kraft polybags containing no moisture retaining material, shingle tow and Tuffex, a moisture retaining blotter paper. They found no increase in survival with the addition of the chemical compounds but Tufflex wrapped around the roots of Douglas fir was superior to shingle tow or no packaging additive. These findings confirmed those of Dick (1964) and Roy (1966) who experienced similar insignificant results with the Rutex products. Also, antitranspirants such as Foligard (Roy 1966) and Silvaplast (Langstrom 1971) used as a moisture loss mitigation technique during handling and storage failed to improve seedling performance. Dimpflmeier (1969) observed that Agricol root dip reduced the amount of seedling desiccation, but that sodium alginate and xanthum gum proved detrimental as moisture retention compounds (Ouston and Stein 1972). Later work by Stein (1977) also shed some doubt on the usefulness of Agricol root dip as did work by Mullin and Hutchison (1977).

Length of storage is important to seedling moisture status (Hammer and Broerman 1967) and the importance of maintaining a high relative humidity in

the storage environment has been clearly identified by Eliason (1962), Tarrant (1964), Lindquist (1970) and Langstrom (1971). Nyland (1972) also suggested that storage temperature and temperature fluctuations can lead to serious desiccation problems during storage. However, the effectiveness of packaging treatments may be influenced by the length of storage. Hammer and Broerman (1967) found no differences between slash pine stored in bales with moss, bales with a clay dip and Kraft-polyethylene bags with no moss, over a four week period. However, only the Kraft-polyethylene bags with no moss stored trees satisfactorily over an eight week period. Mullin and Blum (1975) arrived at similar conclusions when they observed that the addition of moss had no effect over a two week storage period, but was beneficial over a four week period.

Preservation of relative moisture content is important for seedling survival (Faulkner and Aldhous 1957, 1958) and a loss of 40% of fresh weight can lead to reduced viability (Brown 1971). Tarrant (1964) observed that Douglas fir seedlings whose tops were exposed but roots were packed in shingle tow gained moisture over an initial eight week period in a storage environment of approximately 2°C and 95% relative humidity but when slow drying was allowed, roots were demonstrated to be much more susceptible to drying than tops. Hocking and Ward (1972) also noted distinct differences in the drying rates of seedlings when tops only were exposed than when the entire seedlings were enclosed. Seedlings totally enclosed not only lost no moisture, but actually gained moisture during storage. In addition, plant moisture stress values can be substantially lowered by storing seedlings along with a moisture retaining material (Wynia and Woods 1977). Navratil and Dye (1978) also stressed the importance of correct packaging and an adequate amount of moisture retaining material in maintaining satisfactory seedling moisture content.

Water dipping prior to storage is another option. Plant moisture stress readings after storage showed that seedlings dipped in water prior to storage had lower moisture stress values than those not dipped (Ouston and Stein 1972). However, Navratil et al. (1976) suggested that dipping roots in water prior to storing should be used with caution and Mullin (1976) noted that survival of water dipped stock was reduced below that of stock stored with moss. Other experiments also point to a reduction or no difference in post-storage performance when water dipping was used (Mullin and Hutchison 1977, Mullin and Forcier 1977, 1978, 1979; Mullin 1980b, 1981a, 1981b, 1983; Mullin and Myland 1982). Spraying roots with water prior to storage was also not productive (Belli and Dickmann 1985).

By 1970, three methods for packaging bare-root nursery stock were being used in Ontario: 1/ Kraft bag with polyethylene liner and no moisture retaining material, 2/ Kraft bag with polyethylene liner plus a moisture retaining material, and 3/ burlap bales with a moisture retaining material and periodic watering. However, treatments to regulate moisture within the package were still being developed. The addition of free water to a sealed bag was recommended by Slayton (1971) but no documentation of results was made. However, the possible detrimental effects of free water as a source or contributing factor to mould in the storage environment were identified by Hocking (1971).

Finally, Lindquist (1970) found that polybags without moss stored seedlings better than polybags with moss. Many other reports of the lack of effectiveness of moss have also been documented (Jakabffy 1975, Webb and von Althen 1980, Mullin 1980a, 1981b; von Althen and Webb 1981).

In Ontario nurseries many variations of water dipping and/or the addition of moss are presently used. These variations include no moss or dipping, moss added to the top and bottom of the bag, moss added in layers to the bag, moss added with water dipping on hot days only, moss added along with water dipping all the time, water dipping all trees, water dipping selected bundles only and the spraying of roots with water as required. This degree of variation indicates that an operationally effective treatment has not yet been developed.

Location and Quantity of Moss

Not only does the amount and location of moss in the storage container vary for every nursery, but it also varies substantially among lifting crews. In addition, unit foresters and company representatives in Ontario influence the use of moss from year to year through specific requests. Only three reports reviewed for this paper dealt with the amount or location of moss in the package. Williston (1965) examined the response of seedlings stored in Kraft bags along with no moss, 1 lb. of damp moss and 10 lb. of damp moss and found that 1 lb. of moss was as effective as 10. Lindquist and Elliot (1968) and Mullin (1980a) did not detect any differences in performance of seedlings attributable to the location of moss in bags. There was a general feeling that it should be close to the roots but this is not always possible. The main function of moss is to increase or maintain the relative humidity in the storage container and this can be achieved using a relatively small amount of moss located at the top, bottom or middle of the bag.

Moisture Retaining Material and Mould

The possibility of mould during storage and the link between mould and certain storage materials or moisture conditions has influenced packaging, storage and handling operations. A strong line of evidence suggests that excessive moisture or free water is a contributing factor toward the growth and development of moulds during cold storage (Afanasiev et al. 1959, Trampe 1960, Eliason 1962, Aldhous 1964, Hocking 1971, 1975). This includes humidity levels of 95% or greater (Van den Berg and Lentz 1968, Hocking 1971, Nyland 1974a, Venn 1981). The addition of a moisture retaining material has often been correlated with the occurrence of mould, but has rarely been shown to be a causal factor. Deffenbacher and Wright (1954) observed that shingle tow inhibited mould growth while ponderosa pine stored with sphagnum moss had a considerable amount of mould. A similar observation of the somewhat antibiotic effect of shingle tow and peat was observed by Christie (1968) and Hocking (1975) although an increase in mould was reported by Jakabffy (1975) for seedlings packed with wet moss.

It is clear that the most important factors affecting moulds other than moisture and relative humidity, are the storage temperature and temperature control (Duffield and Eide 1959, Wycoff 1960, Mahlstede and Fletcher 1960, Aldhous 1964, Williams and Rambo 1967, Van den Berg and Lentz 1968, Hocking 1971, Nyland 1972, Hocking and Ward 1972, Nyland 1974a, 1974b; Venn 1981, Cram and Lindquist 1981, Racey et al. 1985), followed by the abundance of dead or decaying matter (Wycoff 1960, Nyland 1972, 1974b; Venn 1981), soil particles (Eliason 1962, Hocking 1971, Cram and Lindquist 1981), the degree of dormancy of the stock (Trampe 1960,

Aldhous 1964, Venn 1981, Racey et al. 1985), and the duration of storage (Jakabffy 1975, Venn 1981).

The best insurance the nursery has in avoiding mould damage is to lift clean, healthy, undamaged stock, in a dormant state, package in a vapour proof container and cool immediately to 0.5-2°C where mould development is greatly retarded. If stock is to be stored overwinter in Ontario, frozen (-3°C) storage should be used. The control of mould by fungicide dips has proven only partly successful (Smith et al. 1973) and should be used only in addition to proper handling techniques and storage temperatures.

The Argument For Moisture Retaining Material

The argument for using a moisture retaining material as part of an operational lifting and packaging technique has been well documented in the literature. Duffield and Eide (1959) stated that it was possible to eliminate peat altogether but this had not been done because of the inconvenience to the planters who depend on the peat in bags for their planting bags. A more realistic and prevailing argument for any moisture retaining material is that it provides an insurance factor to guard against unpredicted drying during the lifting and handling procedure. Christie (1968) acknowledges that both shingle tow and peat are good moisture retaining materials but that they are not necessary when trees are wrapped in polyethylene. However, he also notes that it gives a moisture buffer (absorbing excess water or maintaining a high relative humidity) and permits the use of more air. Similar feelings are expressed by many of the nurserymen in Ontario. This insurance factor can not be discarded.

Navratil et al. (1976) stated that every container type requires the addition of moisture retaining material, preferably sphagnum moss. This is to permit the trees to absorb as much water as possible prior to outplanting. Wynia and Woods (1977) also noted a distinct reduction in plant moisture stress with the addition of damp moss in cartons and Stein (1977) observed increased field performance with the addition of a moisture retaining material. Navratil and Dye (1978) pressed for the addition of moss as a means of reducing pre-lifting and pre-packaging water stress, even when stock is packaged with a polyethylene liner. They go so far as to suggest that an adequate amount of moisture retaining material is mandatory.

A final argument for the use of moisture retaining material in modern nursery practice is related to overwinter storage of hardwood stock. Webb and von Althen (1980) suggested that the roots of autumn lifted white ash, silver maple, red oak, basswood, white birch and sugar maple should be surrounded by moist peat and the total seedling tightly enclosed within a Kraft bag with a polyethylene liner.

The Argument Against Moisture Retaining Material

A strong argument is presented in the literature based upon the findings of various trials that moisture retaining materials are not necessary in packaging. The matter of economy is mentioned on a regular basis. Lanquist and Doll (1960) suggested that considerable monetary savings can be made if packing materials, other than the outer covering, were omitted. This is also an opinion expressed by several nursery managers in Ontario.

The most powerful argument, expressed by many, is that the modern polyethylene packaging material is vapour proof and therefore, if a 100% relative humidity is achieved at or shortly after packing, and the trees have a good moisture status at the time of lifting, then moisture retaining materials are unnecessary or potentially harmful (Christie 1968, Hocking and Ward 1972, Lindquist 1970, Mullin and Blum 1975, Mullin 1981a, 1981b, 1983; Mullin and Myland 1982, Belli and Dickmann 1985). However, it should be noted that many authors presenting arguments against the use of a moisture retaining material have expressed some reservations. These usually pertain to the insurance factor as discussed earlier to guard against irregularities in lifting and handling so often found in operational nursery practice.

The Argument Against Moss

A problem pertaining to the use of sphagnum moss is the possibility of the spread of Sporotrichum schenckii, a soil fungus which can cause an occupational disease known as sporotrichosis. Slayton (1971) cites this as a major reason for adopting Kraft bags as an alternative to sphagnum moss after two cases of the disease were reported in 1968 and four in 1969. Skilling (1983) gives a first hand account of the disease including its causes, symptoms and treatment. Other excellent accounts of outbreaks of the disease, along with possible causes, or linkages to the use of moss are also available (D'Alessio et al. 1965, McDonough et al. 1970, Powell et al. 1978, Remington et al. 1983, Phair 1987). The threat of this disease has eliminated the use of sphagnum moss at state nurseries in Wisconsin where the fungus is endemic.

By far the most prevalent argument against the use of sphagnum moss is the same as that for most other moisture retaining materials in polyethylene bags; they don't have any beneficial effect. Several reports of no beneficial effects from the addition of moss have been reported (Mullin 1956, Aldhous 1959, Eliason and Carlson 1962, Williston 1965, Lindquist 1970, Hocking and Ward 1972, Mullin and Blum 1975, Jakabffy 1975, Mullin 1980a, 1981a, 1981b).

Finally, the argument against the use of sphagnum moss receives further support from observations of increased mould when moss is used (Deffenbacher and Wright 1954) although this discussion has been presented in some detail earlier.

Alternatives to Moss

The alternatives to moss are many, most of which simply act as a replacement moisture retaining material. The alternatives can be broken down into three groups; natural, manufactured and procedural.

The natural alternatives all have similar properties and use as moss in that they retain moisture and are usually organic. These products include vermiculite, sawdust, shingle tow, poplar wood excelsior and chopped hay. The "Seedling Pak" is a manufactured product which consists of sheets of water retaining wood fibre felt (Jankowski 1966). The procedural alternatives are specific treatments applied directly to seedlings. These include the Rutex root and foliage dips, Shell 4901 foliage dip, clay slurry or mud root dips, foligard spray, sodium alginate dip, xanthum gum dip, water dip and dry packaging. All of these have been discussed in some detail earlier.

The only two realistic and plausible alternatives to packaging with moss are root dipping in water and packaging dry.

Conclusions

Ontario nurseries have already taken the largest single step in preserving the moisture status of stored bare-root seedlings by using the Kraft bag or the cardboard carton with the polyethylene insert as their main packaging medium. The most important feature is the sealed, vapour proof polyethylene liner within a protective enclosure. It is also clear from the literature reviewed that only the biological facts, and not such features as minor economic arguments or convenience should be the factors that govern the use of moss or any other moisture retaining material. The maintenance of high seedling quality should be the most important concern when the use of moss is considered. Finally, there is abundant evidence to suggest that most stock types have similar requirements for short term storage and that any decision based on biological facts should be applicable province wide, so that all nurseries are governed by the same high standards of planting stock handling.

The following conclusions have been derived from the literature.

1/ The most important factor governing packaging, storage and handling of bare-root nursery stock is the maintenance of high relative humidities (95-99.9%) in the storage environment that the trees are directly exposed to. Other factors such as root exposure, rough handling or temperature extremes are also critical.

2/ High relative humidity can only be maintained in open storage systems (burlap bales and wooden crates) by the addition of an adequate supply of moisture retaining material and periodic watering.

3/ High relative humidities can be maintained in closed storage systems such as the Kraft bag with the polyethylene liner without the addition of a moisture retaining material, provided the stock has good moisture status at the time of lifting and a high relative humidity is present at, or very shortly after the time the bag is sealed.

4/ Mould is not caused directly as a result of moss and can be controlled by lifting dormant, clean, healthy stock, eliminating excessive soil and dead organic matter and effecting good temperature control.

5/ Sporotrichosis, as an occupational disease needs to be considered as a potential health problem for nursery workers in an endemic area when the use of moss is being considered.

6/ The operational use of moss at Ontario nurseries lacks uniformity and is sometimes inconsistent with the biological facts.

7/ Moss is not necessary under good, sound and well controlled spring lifting and storage conditions if a Kraft bag with a polyethylene insert is used.

8/ Water dipping is not necessary under good, sound and well controlled spring lifting and storage conditions if a Kraft bag with a polyethylene insert is used, but may be desirable when plant water stress at time of lifting is too high, providing that it does not lead to free water in the bag.

9/ Under sub-optimal lifting conditions, water dipping, even when applied properly, is no more beneficial than the addition of moss.

10/ Water dipping is more likely to cause problems and is improperly applied more frequently than the addition of moss. Operational water dipping usually produces free water in the bag. Damp, not wet moss, releases water vapour as required or absorbs excess water if present.

11/ Moss may be useful in bags of stock opened periodically or planted over a length of time. This is usually the case with research trials and many private tree orders.

12/ The length of storage period and degree of temperature fluctuation within the storage environment may affect moisture relations of the seedlings, although the mechanics of moisture problems under these circumstances are not fully understood.

13/ Spring storage and overwinter frozen or cold storage are two distinct storage regimes. The condensation and vaporization of water due to the temperature changes associated with overwinter storage may make a water reservoir, such as a moisture retaining material, necessary.

14/ A widespread opinion among nursery people and researchers is that the addition of moss provides a certain degree of insurance or a safety factor against faulty handling practices or flawed packaging. This is strictly an opinion, but a widespread one.

15/ It is also a widespread opinion among nursery people that moss is not essential for good performance or survival in the field.

16/ The location or amount of moss has little or no effect on the packaged seedlings or their eventual performance.

17/ Conclusions based upon results of limited and highly controlled research trials do not necessarily apply to less well controlled operational conditions. Therefore, caution should be used in interpreting the literature.

Recommendations

1/ Moss and water dipping are not necessary in spring packaging if the moisture status of seedlings is satisfactory and a high relative humidity within the bag is achieved upon sealing. This can be facilitated by removing as much of the air as possible from the polyethylene liner and ensuring that the liner is securely sealed. A suitable moisture status can be achieved by irrigating the compartment to field capacity 24 hours prior to the commencement of lifting. Nursery beds should not be undercut more than 1/2 hour prior to lifting.

2/ All nurseries should have a supply of damp moss or a rehearsed water dipping procedure on hand at all times to be used if drying conditions in the nursery are such that the moisture status of the trees becomes reduced or the possibility of achieving 95-99% relative humidity within the bag is threatened. Water dipping, if used, should be well monitored to ensure that excess water is removed prior to packaging.

3/ Moss should be added to all private orders to ensure that relative humidity within packages is maintained when packages are repeatedly opened as is frequently the case with private orders. This practice also indicates to the purchasers that the stock has been treated with care.

4/ Nurseries must actively pursue the goal of achieving good moisture status in stock prior to lifting, by irrigating, studying environmental records, exercising closer control of the length of time between undercutting and lifting, and minimizing root exposure during packaging and pruning. The development of a reliable and practical method of determining the water status of the stock should be encouraged.

5/ For fall lifting, a handful of moist, not wet, sphagnum moss should still be added to the bag during packaging. This is to ensure that the unknown factor of condensation and vaporization due to temperature fluctuation does not expose the trees to periods of low relative humidity, during or after frozen storage. Water dipping should not be used in lieu of moss for fall packaging.

6/ More awareness and/or precautions should be taken to prevent the occurrence of sporotrichosis among nursery workers and tree planters.

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